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ABSTRACT

The program described in this paper was designed to address two sets of questions, one concerning the nature of classroom teaching and learning of science in secondary schools and the other concerning their mechanisms. The program consisted of four phases: (1) "Establishment" (emphasizing trust between teachers and consultants); (2) "Directed Training for Reflection and Action Research" (developing techniques for increasing teachers' project comprehension;) (3) "More Autonomous Teacher-Initiated Collaborative Action Research" (listing all the factors that might influence students' attitudes and application in years 7-11, and forming working groups to deal with different factors); and (4) "New Partners--Students Joining Consultants and Teachers as Researchers." A major insight is that the relative importance of factors changes with time, individuals and context. Other insights include the diversity of students' reactions to lessons and the fact that teachers' impressions of the reactions are often misleading. The shift in responsibility from consultants to teachers and students is described. Questions from the "What I Think of Science" instrument and "Year 9 Agreement on Science Teaching and Learning Weekly Evaluation Form" are provided in the appendices. (YP)

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# TEACHING AND LEARNING SCIENCE IN SCHOOLS:

# AN EXPLORATION OF PROCESS

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**APPENDIX A:**

# TEACHING AND LEARNING SCIENCE IN SCHOOLS :

# AN EXPLORATION OF PROCESS

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Research on teaching and learning has often been criticised for its failure to illuminate or affect classroom practice. It has been castigated for using brief interventions and for being artificial. In reaction to these criticisms our recent and current work is action research with teachers and pupils, in very long term studies of the operations of typical classrooms. We have been involved in two major programs, as well as some smaller ones (e.g. White, Bakopanos & Swan, 1988). Since the first major program, the Program for Enhancing Effective Learning (PEEL), has been the subject of several reports (Baird & Mitchell, 1986; Baird, Mitchell, and Northfield, 1987; Mitchell & Baird, in press; White, 1988; White & Baird, in press) it will be summarised briefly before the main part of the paper is given over to the second program.

PEEL began with 10 teachers of diverse subjects in one high school in 1985. The present authors were either teachers or consultants in the project. The aim was to increase the students' understanding of and control over their own learning, so that they would become more purposeful and fulfilled learners. Numerous innovations in classroom practice were adopted and invented by the teachers who, with the consultants, met regularly to share experiences and ideas. Although PEEL was not evaluated rigorously, we believe that it was outstandingly successful in promoting professional development of the teachers involved and did improve the quality of learning by many students. Certainly it provided many insights into the complex issues that arise when innovations are proposed for schools and into the factors that determine the success of practice.

Research has outcomes that relate to the academic researchers as well as those for the teachers and pupils. PEEL produced in us a desire to know more about the minutiae of classroom operations - what sorts of actions by teachers and students matter, and how do they interact to promote or inhibit learning? This was the genesis of the second major program, which began in 1987 with nine science teachers and their students in two secondary schools in the outer north-eastern suburbs of Melbourne.

The program was designed to address two sets of questions, more or less simultaneously. One set concerned the nature of classroom teaching and learning of science, the other their mechanisms. The first set included:

What is it, to be a science teacher (or student)?

What is science teaching?

What is science learning?

What is the most important pay-off in science teaching (or learning)?

What is the worst aspect of science teaching (or learning)?

These were to be tackled through phenomenological reflection by students and teachers, with information gathered through interviews, discussions in and out of class, diaries, and written tasks.

The second set, to be tackled through some form of collaborative action research such as had been followed in PEEL, was to be more directly focussed on details of practice:

How does an observer's judgement of aspects of a teacher's (and a student's) intellectual competence,such as attitudes, perceptions, conceptions and abilities, compare with the teacher's (or student's) own assessment of them?

How well, in the judgement of an observer, are these attributes employed in the planning and conduct of lessons, and how does the observer's judgement compare with the teacher's (or student's) self-assessment?

The observer's judgements were formed from interviews and observations of classrooms; teachers' and students' self-perceptions of competence and performance were obtained from interviews, in-class discussions, diary entries, and written evaluations; and information on the interactions of teaching, learning, subject matter, and school and classroom context came from interviews, observation, discussions and questionnaires.

The two sets of questions, on personal reflection and on reflection on practice, were not pursued in separate phases of the program. Action on both proceeded more-or-less simultaneously and continuously. It is possible, however, to distinguish phases in which different actions occurred.

Phase 1: Establishment

Outsiders cannot hope to do anything useful simply by walking into a school and exhorting teachers to reflect and to engage in action research. Trust has to be established, and the newcomers must learn about the context which they are to join. Therefore the first phase of the program was one of non-intervention, other than through discussion and passive observation. The consultants, authors of this paper, visited the schools often. The greatest involvement was by Baird, who spent two or three days a week at the schools. As well as establishing conditions for further development of the program, these interactions between the outside consultants and the teachers indicated that the teachers were, in the main, satisfied with their chosen profession and with their school, colleagues

and students. However, they acknowledged that there were shortcomings in their teaching and the students' learning which they hoped to redress through participation in the program. That acknowledgement, with the concomitant willingness to take on responsibility for the program so that it became the teachers' project as well as the consultants', was a necessary step before the next phase of phenomenological reflection and action research could begin.

Phase 2: Directed Training for Reflection and Action Research

In phase 2 the teachers, guided by the consultants, developed techniques that increased their comprehension of the project, and took over some of its direction. The students remained in a substantially passive role.

The teachers, together with the consultants, chose to study the teaching of energy. Energy seemed appropriate because it is a central topic in all sciences and was part of the science syllabus at all levels in the schools. The teachers began reflection by writing responses to statements they had devised. For one school the statement was:

> Reflect on where energy crops up in the curriculum -
> what would have been realised or not realised by teachers?
> For each area, include everything that relates to energy.

For the other:

> Describe how energy is currently taught, and
> give your personal views on how energy should be taught.

The teachers said that they found this self-imposed task difficult, and after completing it called for more information about reflection and metacognition. The consultants supplied them with descriptions of earlier research, including summaries of PEEL, which previously had only been

alluded to. This helped:

> 'After reading the articles I now have a better idea of the project. I feel at this stage that the 'group collaboration and support' area is lacking at [name of school]. There needs to be more of an attempt for us as science teachers to talk with one another about the project and where we are heading. We need a meeting time but also just informal talks or chats about the project. I will endeavour to do this more often and hopefully we can share our ideas more. Time of course (or lack of it) is the real problem. I feel that I haven't contributed anything much yet, but once I really get started I hope to make progress and input into the project.'

Many teachers at this stage expressed the need for group meetings to share perspectives, information, and experiences. In collaboration with the consultants, the teachers decided to hold regular meetings at roughly fortnightly intervals. The teachers requested that these meetings be organised and run by one of the consultants, Baird. This was because they did not yet feel that they had sufficient grasp of the nature and scope of the project to determine meeting agenda and direction.

As well as the group meetings there were frequent meetings of each teacher separately with Baird. These individual meetings were designed to help teachers practise reflection. They centred on a cartesian diver apparatus, which the teachers were invited to watch, consider, and explain, and three energy tasks that had also been used with pre-service student-teachers. The aims were:

1. To infer teachers' processing strategies and their attitudes to, and conceptions of, some aspects of energy.

2. To have teachers reflect on their own performance, and evaluate personal attitudes and conceptions.

3. To have teachers compare their performance with that of others by reading Baird, Fensham, Gunstone, and White (1987).

4. To discuss their findings with the consultant and, thereby, to practise 1:1 collaboration.

5. To take these findings into account as they complete their written task related to the teaching of energy.

6. To share experiences and outcomes from the above process at a project group meeting.

It is noteworthy that these experienced teachers were willing to subject themselves to a probe of their understanding of their subject. That they did so marks an advance in their readiness to reflect. Their willingness is made more significant by the difficulty they had with the tasks. Only four of the nine could explain the cartesian diver adequately, and they struggled with the energy tasks also.

Interviewer: Why do you gain weight when you eat chocolate?

Teacher: Because of the high number of kilojoules involved in the chocolate - a lot of fat, milk - high calories content.

Interviewer: Are calories energy?

Teacher: ... [pause] I haven't thought about that one, I don't know ... calories release energy.

Interviewer: Are there calories stored in the block of chocolate?

Teacher: No ... I suppose when you take them into your body and digest them, I don't know, but I suppose there must be, it must have a certain content ... I'm not too sure.

Most of the teachers recognized that their understanding of energy was deficient, and expressed concern about the implications for their teaching:

> 'No, I don't think I have a good grasp of energy ... I find it very difficult [to teach], so I usually spend only a short time on it ... assuming that someone else along the way will pick it up for me, but I'm gradually realising that that is not the case.'
>
> 'I guess our teaching of energy avoids the tricky bits, and so the teaching of energy is therefore superficial.'
>
> 'Do I know anything about energy? Do I use the word correctly? I don't know.'

It was clear that energy was too demanding a focus for the teachers at this time. Threatened by the inadequacies in understanding that had been revealed, they might have withdrawn from the project if they had been pressed to continue working on energy. The overall effect of the experience was, however, positive. Benefits resulted. One of the most important was the increase in the teachers' readiness to focus on learning, rather than on teaching. These were experienced teachers, who had not for years been tested on their knowledge. Naturally they had come to think about the interplay of teaching and learning from the teacher's side. On being tested, they experienced the feelings of uncertainty and confusion and inadequacy that they had forgotten were the reactions of their students.

The experience led them to appreciate a constructivist perspective for managing and directing change. Teachers were now more clear about the need to change by building on current understandings. Their experiences, particularly from the interview, demonstrated to them that

personal change is necessary in order to generate understanding and that this understanding is necessary for effective teaching. Further, teachers came to realise the importance of support from others when undergoing change. For many of them, the energy interview had been unsettling, as it challenged their self-perceptions of their teaching and research abilities. This challenge was diminished through supportive collaboration with others.

The second major aspect of the benefits accruing from these experiences related to the management of the project itself. For the authors, an important lesson had been learned. This lesson was that the demands on people who are undergoing change must be matched carefully to their current intellectual competence to meet these demands.

The energy experiences also caused the consultants to re-define the project aims and to propose new procedures. The main aim was restated as

> To increase our understanding, through collaborative action research, of
>
> (Teachers) the process of teaching, the nature of successful teaching, and ways of increasing the incidence of successful teaching;
>
> (Students) the same three, only with learning replacing teaching;
>
> (Everybody) the relations between teaching and learning.

A process of two-stage reflection on practice was devised, to help teachers and, later, students, acquire research skills. The first stage would be limited to reflection on actual classroom events; theoretical implications would be held over to the second stage.

The consultants and teachers collaborated on a trial of three lessons by each teacher, designed to increase expertise in reflection on practice. The teachers prepared and taught the first of the three lessons in their usual way. Afterwards they wrote answers to these questions:

What was the topic?

Why were you doing it?

How did you go about teaching it?

How well did the lesson go?

- was it successful?
- did the students understand the work?
- was it clear to them?
- was it enjoyable for them?

Baird observed the lessons, and answered the same questions. Then the teacher and Baird compared their perceptions.

The same procedure was followed in the second lessons, with the addition that each of the students completed the form shown in figure 1.

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We would like you to consider today's lesson in science, and answer the following questions.

1. WHAT DID YOU DO? (That is, what was the topic that you were learning?)

2. WHY WERE YOU DOING THIS TOPIC?

3. HOW DID YOU GO ABOUT LEARNING THIS TOPIC? (i.e. what activities did you do in order to learn it?)

4. HOW WELL DID THE LESSON GO? (Answer: Yes or no, and why)
   Was it successful - did you understand the work?

   Was it clear?

   Was it an enjoyable lesson?

Figure 1. Students' response form, three-lesson trialling.

After the lesson, the consultant collated the teacher's, and all the students', responses and returned the collated material to the teacher. The teacher and the consultant then considered together the meaning and significance of the findings.

There was one more addition for the third lesson. Beforehand the teachers predicted the outcomes by writing answers to the questions that they had answered after the first two lessons. The post-lesson discussion between teacher and consultant then took into account the teacher's prospective and retrospective perceptions, together with those of the consultant and all the students recorded after the lesson.

After each lesson, teachers were encouraged to document their experiences in their diary. In addition, teachers wrote answers to the two questions: 'Was the trialling a successful learning experience for me?', and 'Is this procedure an acceptable and appropriate research method for teachers?'

While the teachers and the consultant derived numerous benefits from the procedure, it proved rather unsettling for the teachers. In the words of one teacher, it proved to be 'another humbling experience'. Many students seemed to have little idea of the answers to such questions as 'Why were you doing the topic?', and their ratings for question 4 (see Figure 1) were often negative. Also, there was often considerable disparity between the teacher's, consultant's, and students' responses to question 1, 2, and 3.

However, all the teachers valued the experience. They believed that it had made them reflect more deeply about their practice, and that this enhanced reflection had led to positive change in their classroom attitudes, awareness, and actions.

Here are some selections from oral comments and diary entries:

One teacher: Year 9 Science
During second discussion:

'The way I did that lesson is different from what I would have done before we started all our discussions. What I probably would have done originally would have been to go through the sheets with them, probably at length, for which most of the class would have listened, and some wouldn't have, and then they would have gone ahead and done it. ... I modified the approach and said "You go ahead and read it, and if you get stuck, ask" - I think this involved most of them - I was surprised, even the kids in the back ... got down to it. I was interested to note, too, that they work at very different speeds ... I thought it worked quite well - I thought I was quite superfluous - I was supposed to be the teacher, and I wasn't doing anything! - all I was doing was wandering around, saying "well done", and such. ... I was very pleased with the way it went ... they must be learning, they must be doing it themselves ... they asked for directions, for example "I can't understand this part of the worksheet" - they asked! ... the kids who were asking for help - I had time to give them help.'

Another teacher: Year 10 Science
During first discussion:

'T: That's an interesting statement you just made: "Think about the lesson before you do it" - that's exactly what doesn't happen - I don't have time to think about every lesson before I do it ... I've started writing down why I was doing the lesson, and then I thought "Why the hell was I doing it?" ... I can never remember which class I've given notes to, sometimes I give the same set of notes in a different form, and they [the students] don't say anything! ...

I: Were you satisfied with the lesson?

T: I wouldn't want to be in Year 10 and have to do it, because it's so ... dry and irrelevant for most of the kids.

I: Why are you teaching it, then?

T: It's on the syllabus, and it's important for those students who are going on to Year 11 next year.

I: But didn't you draw up the syllabus?

T: Yeah, I did.

During third discussion

'It's been good. ... Well, I must say that it's started making me think about teaching to some extent.'

An impression gained during the trials changed the immediate focus of the project. The trials involved Baird in close observation of 27 lessons with students from years 7 to 11. He noted that the higher the grade the less the students appeared to contribute in lessons. Subsequent discussions with students supported this conclusion. The teachers then picked up a suggestion from the consultants that the reasons for the trend might be investigated. This ushered in phase 3.

Phase 3: More Autonomous, Teacher-Initiated Collaborative Action Researh

This phase began late in 1987 and continued through the early part of 1988. It involved a further increase in the responsibility that the teachers took for the research, though the consultants maintained a leading role.

The teachers and consultants listed all the factors that they thought might influence students' attitudes and application in years 7 to 11. They indicated their perception of the importance of each factor, and

whether it was under their control and whether it would be interesting to study it. While the teachers freely identified possible factors, they were less confident than the consultants in judging whether each could be researched. Their willingness to take more responsibility for the project had grown, but was held back by lack of research experience. The consultants helped them determine which factors were generally regarded as more important and which were researchable.

The teachers and consultants formed working groups that would deal with different factors.

School A

Group 1: To develop understanding of student-centred causes (e.g. more polarised science vs. non-science interests, general needs, attributions for success, perceptions of novelty) through questionnnaires and interviews. (2 teachers, 1 consultant)

Group 2: To explore the effect of teacher dominance of lessons (2 teachers, 1 consultant)

School B

Group 1: To explore the effect of teaching being limited in range to suit those students of perceived middle-ability (2 teachers, 1 consultant)

Group 2: To explore the effect of assessment procedures (2 teachers, 1 consultant)

Group 3: To explore the effects of over-emphasis on facts and insufficient variation in teaching method (1 teacher, 1 consultant)

The meetings that formed these groups and tasks and that determined procedures of research were important steps in the teachers' progress.

For the first time they took an equal share with the consultants of responsibility for deciding what should be done, and the method of research. The students were still not part of the research, other than as respondents to questionnaires.

From the various groups came a total of 988 questionnaires. They confirmed that year by year students become disaffected with science, with marked effects at years 8 and 9. The responses disclosed diverse factors that students perceived to influence their application to science and their enjoyment of it.

While the results are useful in themselves, more important for the project was the effect that the exercise of gathering them had on the teachers. Their written responses to a questionnaire following the exercise indicated confidence in the part with which each had been associated, but lack of an overall conception of the scope and purpose of the research. They needed some integrating theme which would subsume their research findings before they could go on to take further control of the project.

In a discussion in school B at the beginning of 1988, Baird presented a thematic diagram (figure 2) which the teachers accepted as filling their need. They saw that each of their research perspectives and specific studies of interest in science could be accommodated within Baird's representation of factors. The key notion of "challenge" fitted well with their ideas, and allowed for effective discussion. This incident is an example of the way in which academic partners are essential to action research by teachers.

Following the discussion the teachers began to initiate research of their own. One group videotaped discussions in which they probed the

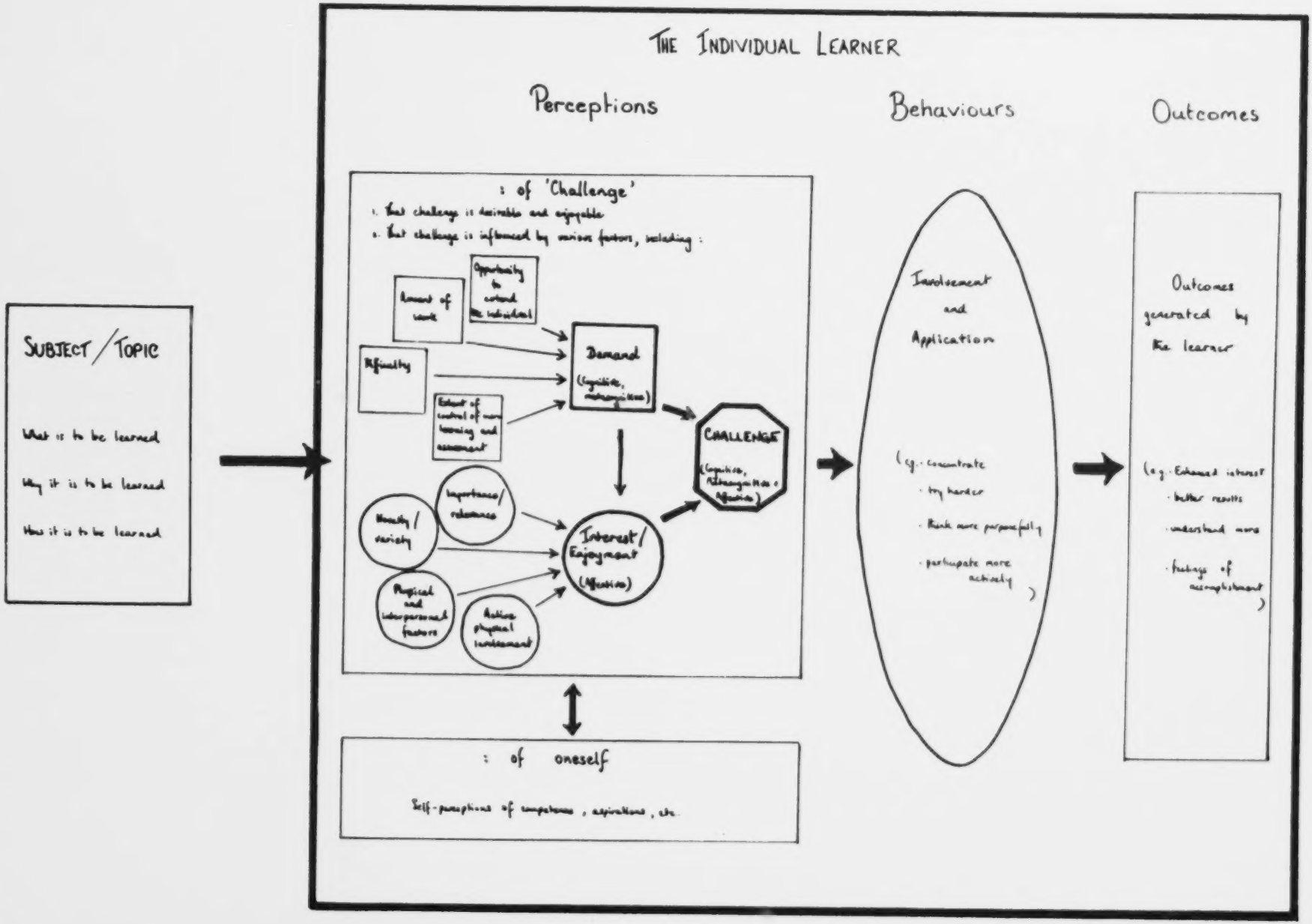


Figure 2. Conceptual scheme



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meanings students have for challenge. Another collaborated with years 10 and 11 students to increase their responsibility for their assessment, and monitored consequent changes in attitudes and behaviours. A third interviewed students to detail factors that enhance interest in science, and changed students' and teachers' classroom responsibilities to accommodate those factors.

Diary entries by the teachers attest to the increase in their confidence to plan and execute research in their classrooms. Their readiness to involve the students as partners, even if as yet unequal ones, in the research is a further indication of confidence. This confidence led three of the teachers to present papers (Ross, Hills, Baird, Fensham, Gunstone, & White, 1988; Baird, Walsh, Gunstone, & White, 1988) at a research conference; none of them had previously spoken at a teachers' conference, let alone a research one.

Growth in confidence, or, one might put it, in professional competence, was associated with willingness to take risks that a year earlier would not have been imagined. These risks are connected with greater involvement of the students in the project, an involvement that merits identification of a new phase.

Phase 4: New Partners - Students Join Consultants and Teachers as Researchers

The teachers wanted to involve the students more in lessons, so that they would be more purposeful learners. They wanted also to improve their own performance. Their solution was to discuss the operation of their classes with the students, an act that required confidence since it had to involve direct or implied criticisms of their professional skill.

The first formal action following the discussions was the preparation and completion of questions designed to capture teachers' and students' perceptions of lessons. The impetus for the questionnaires came from Baird, who also provided most of the detail in their construction. However, the construction did involve collaboration between teachers and students. Examples of the questionnaires are at the end of the paper. They direct attention to interest in science and understanding. They are an evaluation of the teaching and learning, but also served as a method of training in reflection. They were completed three times by four classes, twice by five, and once by four.

Students' responses were informative and direct, as the sample sheet in figure 3 shows. They are difficult to summarise without great loss of information, though consultants and teachers found that reading through them provided insights such as the diversity of reactions to activities and the frequency with which a lesson that the teacher was happy about was less appreciated by the students. The chief outcome was the decision by the teachers to involve the students more directly in the conduct of lessons. At the suggestion of the consultants they did this by discussing with their students improvements that teacher and students could make in their behaviour. From the numerous suggestions that followed, each class chose three improvements for the teacher, three for the students. These were set down as a contract, an agreement to change. For example, in one class the teacher was to:

1. Use more variety in lessons
2. Use simple language
3. Give clear instructions on what to do

Question 3

(a) What was the best thing about science lessons last week?

The best thing was doing the practical exercises.

(b) Why do you think this?

Because it induces us doing something practical and not academic like a lot of the other units.

Question 4

(a) What was the worst thing about science lessons last week?

Trying to understand how to write equations.

(b) Why do you think this?

Because it wasn't explained clear enough.

Question 5

(a) Do you think Mrs is teaching science well?

she does teach well but needs to be a bit more sure of what she is saying. Also explantions need to be more clear.

(b) Why do you think this?

Question 6

(a) Do you think you are learning science well?

Yes, but I need to concentrate hard to understand anything.

(b) Why do you think this?

Because chemistry isn't really a part of science I enjoy.

Figure 3. Sample page from student's evaluation of a week's science lessons

while students were to:

1. Ask more questions
2. Be more supportive of each other
3. Complete work set

The agreements were kept alive by frequent evaluations by the teacher and students of their own and the other partner's performance. A student's evaluation form is at the end of this paper.

The agreement evaluations produced much data. There were 14 classes of 12 teachers, with 316 students in years 8 to 11. Involvement ranged between 1½ and 14 weeks, with a total of 98 class-weeks. A summary of results from the students' forms is given in Table 1. The summary shows that students remained aware of the changes that had been agreed upon, that they perceived that they and the teacher had made the changes, and often that enjoyment and understanding of science had increased because of them. These are encouraging results.

Table 1

Evaluations of Agreements to Change: Responses of Students

Given as Percentages of Classes

| Question | Nature | Median of* Class %s | Range |
|---|---|---|---|
| 1 | Students remembered at least 2 teacher changes | 92 | 53-100 |
| 2 | Students remembered at least 2 of their own changes | 85 | 52-100 |
| 3(a) | "Yes" to having observed teacher changes | 86 | 57-100 |
| (c) | Enjoyment enhanced through teacher changes | 53 | 21-100 |
| | Understanding enhanced through teacher changes | 56 | 21-83 |
| 4(a) | "Yes" to having made change | 80 | 47-100 |
| (c) | Enjoyment enhanced through own changes | 47 | 26-92 |
| | Worked harder through own changes | 54 | 22-83 |
| | Understanding enhanced through own changes | 58 | 27-92 |

* Number of classes = 14, number of weekly evaluations = 49

Interim Comments

The abiding purpose of our work is to increase understanding of the nature and mechanisms of teaching and learning science in secondary schools. We believe we are making progress with that, even though it is apparent that so complex a social enterprise can never be fully described.

A major insight is about the nature of causality. Experimental research through at least the 1950s to late 1970s was based on a simple causal model, that variations in one factor would be followed directly and consistently by changes in another. Even when it was recognized that factors interact, the notion remained that a simple relation could be found between an interaction of a couple of factors and an outcome. Essentially this is a view of cause that pervades the sciences. Experience in the type of research reported here has led the academics and schoolteachers to restructure their conceptions of cause. We now see that the mechanisms of teaching and learning operate in ways that are not immutable or easily generalisable. The relative importance of factors changes with time, individuals, and context. Understanding of classrooms may be enhanced by describing the variation of causal interactions through different circumstances, rather than by seeking context-free laws.

The research has led to an inclusive conception of cause. Thus the fall in interest in science from years 7 to 11 may be due to factors such as insufficient variation in lesson style, teacher dominance, assessment procedures, student needs, competing demands, and peer influences. Which factors dominate will change with circumstances.

These contentions about cause imply that most science teachers will need to undergo a process of significant intellectual development before they can grapple effectively with researching teaching and learning in their classrooms. Indeed, it is unlikely that, at the start of the project,

the teachers would have been ready to approach their research on the Year 7-11 drop off in the way they did several months later. They needed time to accommodate the multiple and variant nature of cause which was implicit in this later approach. Another aspect of the intellectual development required in these teachers, as it relates to conceptions of cause, involves their agreement to engage in phenomenological research. In order to develop a commitment to the notion of phenomenology, teachers may need to change their conceptions of successful science teaching considerably - from one where it is law-governed and generalisable, to one where it develops through a process of individual reflection on personal life experience.

Other, less fundamental, insights include the appreciation of diversity in students' reactions to lessons, and the fact that teachers' impressions of these reactions are often astray. This is an aspect of the more basic notion of causality that has just been described. For instance, many people might subscribe to the proposition that "students appreciate activities involving physical actions with a clear purpose". However, there were mixed reactions to a lesson in which students, according to the teacher, had "an interesting cut-and-paste activity of preparing a karyotype by classifying the chromosomes. Everyone, without exception, worked to a maximum, some stayed behind to finish glueing the chromosomes on their sheet and all others decided to complete their task at home." While many students said they enjoyed this, many others said that it was boring, often because they thought that the scientific principle was clear enough to them without having to engage in a rather artificial exercise.

In addition to illuminating aspects of teaching and learning, the project has taught us much about the method of action research. It is clear now how much change has to occur in teachers (and to some extent in academics) before an action research project can work, and that this change requires time and the support of a group that consists of both colleagues and outside consultants.

The change involves a shift in responsibility. Figure 4 contains a summary of the types of responsibility that have to be carried. For most of 1987 the non-teaching consultants carried responsibilities A and B, for organization and conceptual guidance. Had we not done so, we believe that the project would have languished. Conceptual guidance is particularly demanding, as it requires experience in professional reflection and in classroom research. With experience, and observation of the modelling of responsibilities A and B and the confidence that came from sharing responsibilities C and D, the teachers developed so that all responsibilities came to be shared more equally. At the same time the consultants learned, too, about how to meet these responsibilities better themselves.

Responsibility A. Organisation/Administration

This responsibility involves such things as: arranging and organising meeting times and agenda; providing necessary materials; collating and analysing data.

Responsibility B. Conceptual guidance

'Conceptual guidance' includes:

B1. Goal setting and planning

e.g. Establishing the general research purpose and focus, setting the manner and direction of research, and determining (devising, adapting) research methods and techniques.

B2. Information-giving

e.g. Providing information on appropriate techniques and theoretical perspectives.

B3. Conceptual organisatin and evaluation

e.g. Interpreting and evaluating data; organising patterns of results within a conceptual framework; devising or adapting theoretical perspectives.

Responsibility C. Reflection and collaboration on practice

Sharing perspectives on the 'What', 'Why', 'How', and 'How Well' of classroom practice, e.g. the 3-lesson trialling of Stage 1 reflection on practice, to be discussed in Phase 2.

Responsibility D. Support

The provision of interpersonal or group support during change, e.g. to share uncertainty, to acknowledge effort, to commiserate in failures, to reward successes.

Figure 4. Types of responsibility in collaborative action research.

A similar growth in responsibility by students may never occur to the same extent, but some movement did occur in phase 4. This shift requires confidence by the teachers and the students that they can cope with deep probing of their beliefs and with revelation of other people's views of them. Establishing that confidence is another thing that takes time and support. It is to the credit of the teachers in this project that they have allowed students to comment on the quality of their teaching, and have not wanted in reports such as this to disguise their identities by pseudonyms.

A further unplanned outcome, though one that experience with PEEL led us to expect, was the professional growth of the teachers, which two brief recorded comments illustrate:

> 'I reflect on what I am doing more. I'm following up a lot of what I do now ... I look back [on my teaching performance] and analyse it ... it's been a real personal development.'
>
> 'It's not just teaching - it's other things, outside of teaching ... this project has altered my way of thinking completely ... I used to teach right out of the book, but now I don't teach that way.'
>
> (Comments in discussion, May 1988)

The discursive nature of this report may have made apparent some general properties of long-term action research. Because it is a partnership, and because it deals with a complex situation, at the outset only the general purpose can be determined; details of procedure are settled gradually, as experience grows and as it becomes clearer through early investigations and reflections what factors matter. Specific aims shift as insights accumulate. The outcomes are professional growth of

all those who take part, and insights rather than conclusions.

One insight that we have been forming more and more clearly is the crucial importance of context, and participants' perception of context, in determining what happens in classrooms. This insight causes us concern about the generalisability of other insights we have formed. How can we have confidence that recommendations that flow from these classrooms will be effective in other classrooms? That question is the target of our next work.

The notion of "next work" is connected with another property of long-term action research. Because the research is long; involves numerous overlapping investigations; is absorbed in, or absorbs, the normal running of a classroom; and results in real change in the teachers and students, it does not have a neat end. The partnership between consultants and teachers dissolves slowly, as the consultants need to turn to a question, such as generalisability, that requires them to work with new people, and as the teachers' growth reduces the value of the consultants to them. The partnership ebbs away, but the research itself continues in the further reflections and investigations of the separate participants.

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CONFIDENTIAL

DO NOT GIVE YOUR NAME

## What I think of science

Question 1 What did you learn about in science over the last week?

Question 2 Consider your science lessons over the last week.

| | A lot | A bit | Not much | Not at all |
|---|---|---|---|---|
| (a) How much did you look forward to your science lessons? | | | | |
| (b) How much did you enjoy them? | | | | |
| (c) How interesting was the work you did? | | | | |
| (d) How hard did you work? | | | | |
| (e) How much did you understand of what you were doing and why you were doing it? | | | | |
| (f) How much do you like your teacher? | | | | |
| (g) How important is the work you did for you and your future? | | | | |
| (h) How much did you think carefully about what you were doing? | | | | |

Question 3

(a) What was the best thing about science lessons last week?

(b) Why do you think this?

Question 4

(a) What was the worst thing about science lessons last week?

(b) Why do you think this?

Question 5

(a) Do you think Mr. is teaching science well?

(b) Why do you think this?

Question 6

(a) Do you think you are learning science well?

(b) Why do you think this?

APPENDIX B:

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Name:
Date:

Year 9 Agreement on Science Teaching and Learning

Weekly evaluation form

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A. The agreement

1. Miss _____ has agreed to attempt to make 3 changes to the way she teaches your science lessons. What are these 3 changes?

1. _____

2. _____

3. _____

2. You have agreed to attempt to make 3 changes to the way you learn in your science lessons. What are these 3 changes?

1. _____

2. _____

3. _____

---

B. This week's results

3 (a) Did you notice Miss _____ making any of her 3 changes in this week's science lessons? (Answer 'Yes' or 'No) ....

(b) If you answered 'Yes', - what changes did you notice?

(c) How would you rate the effects of her changes in (b) on:

* My enjoyment of the lessons:

I enjoyed the lessons more than normal as a result of her changes ☐

Her changes had no effect on my enjoyment of the lessons ☐

I enjoyed the lessons less than normal as a result of her changes ☐

* My understanding of the lessons:

I understood the lessons more than normal has a result of her changes ☐

Her changes had no effect on my understanding of the lessons ☐

I understood the lessons less than normal as a result of her changes ☐

---

4. (a) Did you make any of your 3 changes in this week's science lessons?
(Answer 'Yes' or 'No') ...

(b) If you answered 'Yes' - what changes did you make?

(c) How would you rate the effects of these changes on:

My enjoyment of the lessons:

* I enjoyed the lessons more than normal as a result of my changes ☐

My changes had no effect on my enjoyment of the lessons ☐

I enjoyed the lessons less than normal as a result of my changes ☐

How hard I worked during the lessons:

I worked harder than normal as a result of my changes. ☐

My changes had no effect on how hard I worked. ☐

I worked less hard than normal as a result of my changes. ☐

My understanding of the lessons:

I understood the lessons more than normal as a result of my changes. ☐

My changes had no effect on my understanding of the lessons. ☐

I understood the lessons less than normal as a result of my changes. ☐

5. What did you enjoy most about science this week?

6. What did you enjoy least about science this week?